Quick Example of Benefits of Pairing Trajectory Accuracy Data

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What is the Goal?

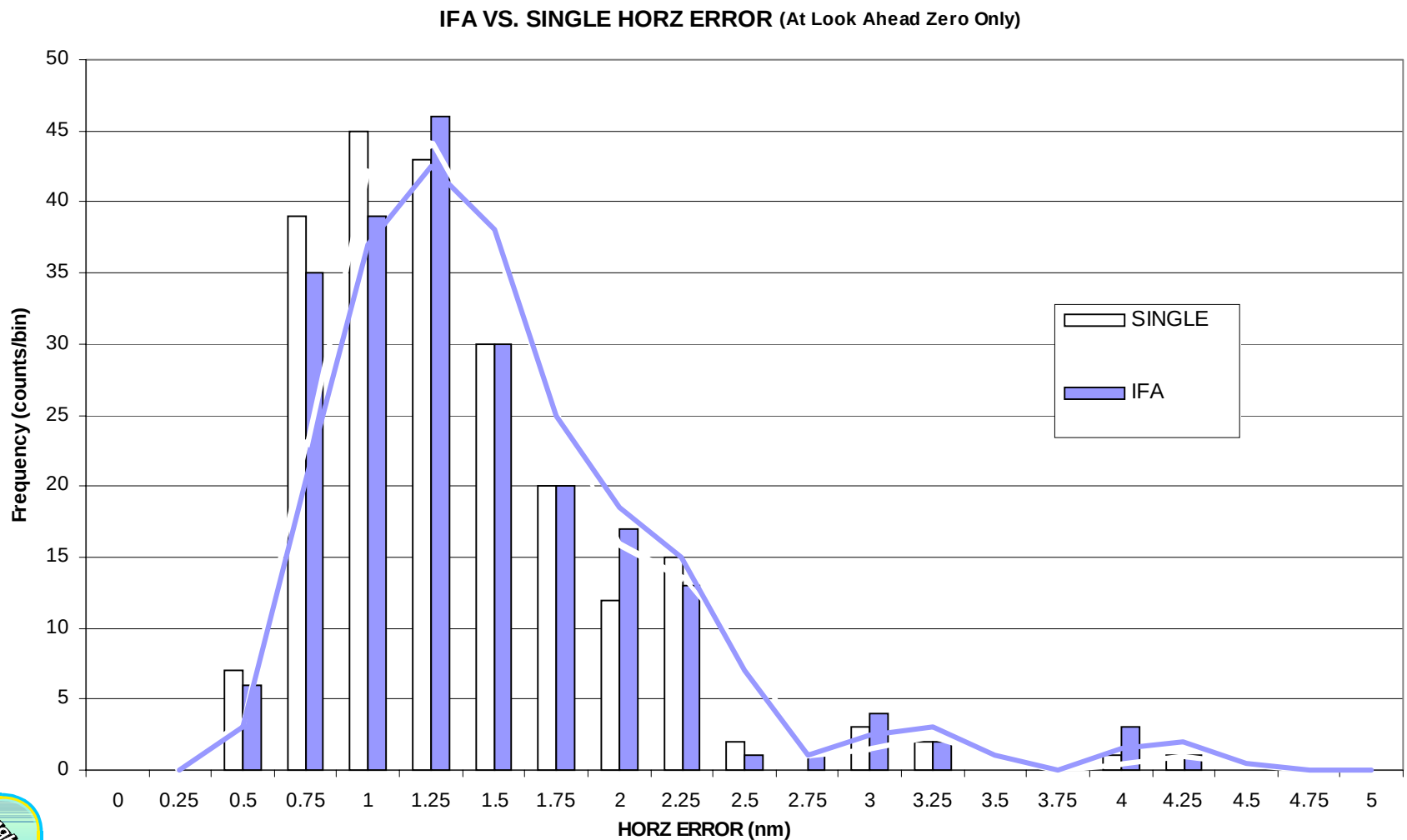
Determine that if running in interfacility mode with ZME and ZID, URET DU has a statistically different horizontal trajectory error than running with ZME in single site mode (with at least 0.05 confidence).

Description of Experiment

- Used 1 hour Initial Delivery Scenario
  - Ran ZME / ZID interfacility run
  - Ran ZME single site run
- Collected each of ZME's SSGs and Ran Trajectory Accuracy Analysis
  - Used all error horizontal accuracy data
  - Facilitated by Oracle 'select' command[1]

[1] select avg(horz_err) from traj_metrics group by look_ahead_tm, acid_cid.

Compare Distributions Graphically



Compare Distributions Statistically

- Sample Mean per Flight at Look Ahead Time of Zero
- Sample Statistics for IFA
  - Mean Horizontal Error = 1.35 nm
  - Standard Deviation of Horz. Error = 0.92 nm
  - Sample Quantity, n = 220 flights
- Sample Statistics for Single Site
  - Mean Horizontal Error = 1.23 nm
  - Standard Deviation of Horz. Error = 0.60 nm
  - Sample Quantity, n = 220 flights

Perform Hypothesis Test

- On means assuming unequal variance
- Use Smith-Satterthwaite Test (Devore, 1987)
  - Test Statistic = t' = [Avg(IFA) - Avg(Single)] / [sqrt (Stddev(IFA)^2 / n + Stddev(Single)^2 / n)]
  - Reject Hypothesis if t' >= $t_{0.025,dof}$ or t' <= -$t_{0.025,dof}$
  - DOF = degrees of freedom ~
- Results
  - t' = 1.615
  - $t_{0.025,379}$ = 1.966
  - P-value = 0.107
- Conclusion: No Significant Difference between Means at 0.05 Confidence

Alternative Hypothesis Test

- Test Difference between Flights of IFA vs Single
- Apply Paired Data Test
  - Calculate difference , d, for each flight/look ahead
  - Sample Quantity of d's = n
  - Test Statistic = tp = [avg(d)] / [stddev (d)/ sqrt (n)]
  - Reject Hypothesis if tp >= $t_{0.025,n-1}$ or tp <= -$t_{0.025, n-1}$
  - DOF = degrees of freedom = n –1
- Results
  - tp = 2.29 and n = 220
  - $t_{0.025,221}$ = 1.97
  - P-value = 0.023
- Conclusion: Is a Significant Difference with 0.05 Confidence, Reject Hypothesis!

Why Difference in Results?

- "If there is a great heterogeneity between subjects (large variance) and a large correlation within subjects, then the loss in degrees of freedom will be compensated for by the increased precision associated with pairing …" (Devore, 1987)
- Flight Accuracy Between Runs not Independent
- Variance is Large Between Flights

Pairing Improves Precision

- Compare Each Confidence Interval
  - Paired CI
    - ✓ Avg(d) +/- $t_{0.025,n-1}$ (stddev (d)/ sqrt (n))
    - ✓ 0.012 +/- 0.103 = [0.02, 0.22]
  - Pooled or Independent Analysis CI
    - ✓ [Avg(ifa)-Avg(single)] +/- $t_{0.025,v}$ [sqrt (Stddev(IFA)^2 / n + Stddev(Single)^2 / n)]
    - ✓ 0.012 +/- 0.146 = [-.03, 0.27]
- Conclusions
  - Any decision made on independent CI is a third less precise!
  - Independent CI includes error between flights as well as between runs, while paired CI blocks between flight error and focuses on runs only!

References

- Devore, Jay L., *Probability and Statistics for Engineering and the Sciences*, Second Edition, 1987.
- Montgomery, Douglas C., *Design and Analysis of Experiments*, Fourth Edition, 1997.